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CT coronary angiography: Influence of different cardiac reconstruction intervals on image quality and diagnostic accuracy

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Abstract

Purpose: To prospectively analyze image quality and diagnostic accuracy of different reconstruction intervals of coronary angiography using multislice computed tomography (MSCT).
Materials and methods: For each of 47 patients, 10 ECG-gated MSCT reconstructions were generated throughout the RR interval from 0 to 90%, resulting in altogether 470 datasets. These datasets were randomly analyzed for image quality and accuracy and compared with conventional angiography. Statistical comparison of intervals was performed using nonparametric analysis for repeated measurements to account for clustering of arteries within patients.
Results: Image reconstruction intervals centered at 80, 70, and 40% of the RR interval resulted (in that order) in the best overall image quality for all four main coronary vessels. Eighty percent reconstructions also yielded the highest diagnostic accuracy of all intervals. The combination of the three best intervals (80, 70, and 40%) significantly reduced the nondiagnostic rate as compared with 80% alone ($p = 0.005$). However, the optimal reconstruction interval combination achieved significantly improved specificities and nondiagnostic rates ($p < 0.05$). The optimal combination consisted of 1.7 ± 0.9 reconstruction intervals on average. In approximately half of the patients (49%, 23/47) a single reconstruction was optimal. In 18 (38%), 3 (6%), and 3 (6%) patients one, two, and three additional reconstruction intervals were required, respectively, to achieve optimal quality. In 28% of the patients the optimal combination consisted of reconstructions other than the three best intervals (80, 70, and 40%).
Conclusion: Multiple image reconstruction intervals are essential to ensure high image quality and accuracy of CT coronary angiography.

Keywords: Computed tomography; Angiography; Coronary vessels; Sensitivity; Cardiac; Reconstruction

1. Introduction

Coronary artery disease is a major public health issue, and conventional coronary angiography is considered the gold standard for diagnosis. However, catheter angiography is invasive and carries certain risks. Noninvasive coronary angiography using multislice computed tomography (MSCT) has become a sensitive and accurate modality to assess the coronary arteries in patients with suspected coronary artery disease [1–6] and has the potential for clinical use [7–10]. But identification of the image reconstruction interval with the highest image quality (for each coronary) for reading CT coronary angiograms is time-consuming and requires reviewing multiple reconstructions at different intervals in the cardiac cycle. Thus, the question arises whether a single reconstruction interval or a fixed combination of intervals might yield the same high image quality and diagnostic accuracy in all patients as manually choosing the optimal reconstruction intervals (for each coronary) from a larger number of datasets for each patient. To answer this question we prospectively analyzed the image quality and diagnostic accuracy of 10 CT coronary angiography reconstruction intervals (centered at 0–90% of the RR interval) for each patient in a

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consecutive cohort of 47 patients (altogether 470 datasets) who were referred for conventional coronary angiography because of suspected coronary artery disease.

2. Materials and methods

We prospectively studied 47 consecutive patients who were suspected of having coronary artery disease with CT using 16 mm × 0.5 mm detector collimation. The study population consisted of consecutive patients who were referred for conventional coronary angiography due to suspected coronary artery disease. Patient characteristics are summarized in Table 1. Patients with contraindications to CT imaging (pregnancy, elevated serum creatinin levels) were not eligible for the study. The study was performed as part of an investigator-sponsored trial on noninvasive coronary angiography using CT and magnetic resonance imaging [2] according to the intention-to-diagnose design [11] and the STARD statement [12]. The study protocol was approved by the Institutional Review Board and the Federal Department for Radiation Protection. Written informed consent for the CT examination was obtained from all patients.

2.1. CT protocol

CT was performed prior to conventional angiography on a 16-detector row CT scanner (Aquilion, Toshiba, Otawara, Japan) using a collimation of 0.5 mm, pitch of 0.2, and gantry rotation time of 0.4 s as recently described in detail elsewhere [2]. Further CT scanning characteristics are given in Table 1. A simultaneous ECG was recorded to retrospectively assign the source images to the respective phases of the cardiac cycle (ECG gating) by applying multisegment image reconstruction. Because of the improved temporal resolution using multisegment reconstruction no intravenous or oral betablockers were given prior to the examination [13,14].

2.2. CT analysis

For each of the 47 patients, 10 ECG-gated datasets with a reconstructed slice thickness of 0.5 mm were generated at 10% increments throughout the RR interval with the center of the reconstruction interval being between 0 and 90% resulting in altogether 470 coronary angiography datasets. A research assistant prepared these 470 datasets in a blinded and randomized fashion for analysis on a workstation (Vitrea 2, Version 3.4, Vital Images, Plymouth, MN). Random analysis of the 470 coronary CT data sets was performed by an experienced reader blinded to conventional coronary angiography who evaluated image quality and the presence of significant coronary artery stenoses (at least 50% diameter reduction) on curved multiplanar reformations using an automatic vessel detection tool [15] in all 15 coronary artery segments [16]. Altogether 4 coronary vessels (segments 1–4 (right coronary artery, RCA), segment 5 (left main coronary artery, LM), segments 6–10 (left anterior descending coronary artery, LAD), and segments 11–15 (left circumflex coronary artery, LCX)) were evaluated in each patient. Image quality was assessed as described recently [17,18] on the basis of coronary artery vessel lengths free of motion artifacts (for the right coronary artery, left anterior descending (including the left main), and the left circumflex). Subjective image quality was assessed using a 5-point Likert scale [19] for all coronary arteries (as the mean of the image quality of the segments constituting the respective vessel) in all reconstruction intervals (5 = highest quality, 1 = lowest quality).

Table 1
Patient and CT characteristics ($n = 47$)

Characteristic	
Age (years)	61.6 ± 9.6
Men/women	62 (29)/38 (18)
Body mass index, mean ± S.D.	26.6 ± 3.0
Coronary artery disease present on conventional coronary angiography	45 (21)
CT contrast agent amount (mL)	109.5 ± 10.4
Effective dose (mSv)[a]	12.4 ± 1.5
Heart rate during CT (beats per min)	67.6 ± 11.5
Length of the CT image reconstruction window (ms)[b]	148.6 ± 31.9

Note: Unless otherwise indicated, data are % (*n*) of patients.
[a] The effective dose was estimated using CT-Expo (Version 1.3).
[b] The length of the image reconstruction window varies with heart rate during scanning since multisegment reconstruction was used for improvement of temporal resolution.

2.3. Conventional coronary angiography

Conventional angiography was performed using standard techniques (Integris 3000, Philips Medical Systems, Best, the Netherlands) with the transfemoral approach within 5 days after MSCT. Quantitative coronary angiography was done by using two orthogonal projections to identify significant diameter reductions (at least 50%) in all 15 coronary artery segments [16]. The diameter of the reference vessel on conventional coronary angiography had to measure at least 1.5 mm for a stenosis to be included in the analysis, thus covering all stenoses that are possible targets for revascularization.

2.4. Statistical analysis

A total of 470 CT coronary angiography data sets (10 per patient) were analyzed. Analysis was performed on the per-vessel level with four coronary arteries for each of the 47 patients included, resulting in 188 vessels for each reconstruction interval and altogether 1880 vessel results for all 10 reconstruction intervals.

Nonparametric analysis for repeated measurements [20] was applied for diagnostic accuracy and image quality analysis to account for clustering of arteries within each patient using a multifactorial design (reconstruction interval, vessel, patient gender). Subsequently, the optimal combination of multiple reconstruction intervals for detection of coronary artery stenoses in all four coronary arteries (selection based on image quality in each vessel) was compared with each of the 10 reconstruction intervals alone and the following combinations of reconstruction intervals: 40 + 80, 70 + 80, and 40 + 70 + 80%.